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CHARACTERISTICS OF SPOTTED OWL NEST TREES IN THE WENATCHEE NATIONAL FOREST

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ABSTRACT.—This study describes Spotted Owl (*Strix occidentalis*) nests and nest trees on the east slope of the Cascade Mountains in Washington. We collected data at 85 nest trees and made comparisons of 62 paired nest- and randomly-selected trees. More nests (92%) were in Douglas-fir trees (*Pseudotsuga menziesii*) than expected in comparison to other tree species in the stand. Most nest trees occupied either dominant or codominant canopy positions, and were typically alive and fully intact. Nest trees ranged from 66–700 yr of age; the median age was 137 yr. Nest trees on south-facing slopes were significantly larger in diameter and older than those on north-facing slopes. Trees with cavity and broken-top platform nests were significantly larger in diameter and older than trees that supported other types of nests. Nests originally made by Northern Goshawks (*Accipiter gentilis*) were the most common nest type used by Spotted Owls (55.3%); other nests were located in mistletoe growth (24.7%), in cavities (10.6%), on broken-tops (5.9%), and on large branches (3.5%). The relatively young age and smaller diameter of nest trees used by Spotted Owls in the eastern Cascades is consistent with the characteristics of stands used for nesting and is likely a result of the fire history of this region. The presence of mistletoe clumps and goshawk nests may facilitate occupancy of younger stands that otherwise lack nesting structures.

Características de los árboles donde el búho *Strix occidentalis* construye su nido, en la Wenatchee National Forest

EXTRACTO.—Este estudio describe los nidos, y los árboles donde éstos se construyen, del búho *Strix occidentalis,* en la pendiente oriental de las Montañas Cascade, en Washington. Hemos colectado data de 85 árboles con nidos, y hemos hecho comparaciones de 62 de ellos con otros árboles seleccionados al azar. Más nidos (92%) de los que se esperaba estuvieron en árboles de la especie *Pseudotsuga menziesii,* en comparación con otras especies de árboles de la muestra. La mayoría de árboles con nidos ocuparon posiciones de copa dominante o co-dominante, y fueron típicamente árboles con vida y plenamente intactos. La edad de los árboles con nidos fluctuó entre 66 y 700 años. La media de las edades fue de 137 años. Los árboles en las pendientes que dan al sur fueron significativamente más grandes y más viejos que los de las pendientes que dan al norte. Tanto los árboles con cavidades como los que ofrecen plataforma en el tronco de extremo superior roto, fueron significativamente más grandes y más viejos que los árboles que sostenían otros tipos de nidos. Los nidos construídos originalmente por el Gavilán Azor (*Accipiter gentilis*) constituyeron el tipo de nido más comunmente usado por los *S. occidentalis* (55.3%); otros nidos fueron ubicados en muérdagos (24.7%); en cavidades (10.6%); en extremos rotos (5.9%) y en grandes ramas (3.5%). La relativa tierna edad y el poco diámetro de los árboles

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usados por los *S. occidentalis* en las Montañas Cascade del este, son consistentes con las características de los grupos de árboles usados por estos búhos para anidar, y es posiblemente el resultado de la historia de incendios de esta región. Puede que la presencia de muérdagos y de nidos de Gavilán Azor en árboles jóvenes promueva el uso de florestas nuevas.

[Traducción de Eudoxio Paredes-Ruiz]

Spotted Owls (*Strix occidentalis*) generally nest in old forests characterized by large old trees, large volumes of dead and downed wood, abundant snags, and multi-storied canopies (Forsman et al. 1984). However, in the Wenatchee National Forest (WNF), where fire has strongly influenced the forest landscape (Cobb 1988), Spotted Owls nest in relatively young stands (Buchanan 1991). The characteristics of nest sites in the WNF will be described elsewhere. Here, we describe the nest trees and nest structures used by Spotted Owls on the east slope of the Cascade Mountains in Washington.

STUDY AREA

Our study was conducted on the east slope of the Cascade Mountains in Washington, primarily on the WNF, but including sites under various land ownerships in the region. Much of the WNF is mixed coniferous forest (Franklin and Dyrness 1973, Cobb 1988). The dominant species are Douglas-fir (*Pseudotsuga menziesii*) and Grand Fir (*Abies grandis*), although Ponderosa Pine (*Pinus ponderosa*), Western Larch (*Larix occidentalis*), Lodgepole Pine (*P. contorta*), White Pine (*P. monticola*), Western Redcedar (*Thuja plicata*), and Western Hemlock (*Tsuga heterophylla*) are locally abundant (Cobb 1988).

METHODS

Data Collection. We examined 85 of 103 known Spotted Owl nests from 1988–90, all but four of which contained fledgling owls at least one of the previous four yr.

To evaluate use of nest trees relative to availability at the stand level we collected data at single randomly selected trees located within 400 m of 62 nest trees. For this comparison we included only trees >28 cm diameter at breast height (dbh) because this was the size of the smallest nest tree and we assumed that trees below this size were generally unsuitable for nesting (see Buchanan 1991 for additional details on selection of random trees and plots).

We identified nest tree species and described their condition (e.g., alive or dead, intact or broken stem). Canopy position was determined as dominant, codominant, intermediate, suppressed, or no canopy (e.g., absence of living canopy foliage within the 0.04-ha sampling plot; see Buchanan 1991). The presence of dwarf mistletoe (*Arceuthobium douglasii*) in each nest tree was rated as none, moderate, or high infection in the upper, middle, and lower thirds of the canopy (see Hawksworth and Wiens 1972).

The age of the nest tree was determined by counting growth rings of an increment core taken at breast height. We measured dbh with a diameter tape. A clinometer was used to determine tree, nest, and canopy height. We recorded nest exposure (azimuth) and categorized the nest type (e.g., cavity, mistletoe broom, abandoned hawk nest).

Statistical Analysis. We used paired-sample *t*-tests and the Wilcoxon matched-pair test (Wilkinson 1988), depending on whether transformations were successful in creating normal distributions, to evaluate differences between 62 nest and random comparison trees. Chi-square analysis (including contingency tables) was used to compare categorical variables Because nest exposure was not strongly polymodal we used Rayleigh's test (Batschelet 1981) rather than Rao's spacing test (Bergin 1991) to evaluate the angular distribution. We used the Watson-Williams test to evaluate the relationship between the mean angles of site aspect and nest orientation (Batschelet 1981).

RESULTS

With seven exceptions, Spotted Owls nested exclusively in Douglas-fir trees (Table 1). At paired sites, we found a significant difference in the proportion of used and available tree species. Douglas-fir was used more than expected and all other species combined were used less than expected ($\chi^2 = 22.2$, $P < 0.001$). Most nest trees were either dominant or codominant in the canopy; this was generally true for random trees as well, although the greater number of random trees in intermediate canopy positions (Table 2) resulted in a difference between nest and random trees that was significant at $P = 0.057$ ($\chi^2 = 3.66$, df = 2). The condition of nest and random trees also differed significantly ($\chi^2 = 4.6$, $P = 0.034$), as there were relatively more live, intact random trees and live nest trees with broken tops (Table 3).

Nest trees ranged from 66–700 yr of age; the median nest tree age was 137 yr (Fig. 1). Nest tree age was significantly greater (at $P = 0.064$) than the age of randomly selected trees (Table 4). The 35 nest trees on south-facing slopes were significantly older than 50 on north-facing slopes (median age for south = 165 yr, range = 66–700 yr; median age for north = 127 yr, range = 67–550; Mann-Whitney test, $Z = 2.71$, $P = 0.007$). The median age of 14 cavity and broken-top nest trees (282 yr, range = 135–700) was significantly greater than the 71 others (120 yr, range = 66–545; Mann-Whitney test, $Z = 5.28$, $P < 0.001$). In summary, 11 of 14 (78.6%) cavity and broken-top nests were in trees >200 yr old and 63 (88.7%) of the

Table 1. Tree species used for nest sites, and a comparison of the number used and "available" at randomly sampled Spotted Owl nest stands and sites in the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison.

			Paired Sites[a]	
Species	All Nests[b]	%	Nest	Random
Douglas-fir	78	91.8	56	31
White Pine	2	2.4	2	0
Grand Fir	1	1.2	0	18
Western Larch	1	1.2	1	6
Ponderosa Pine	1	1.2	1	4
Western Redcedar	1	1.2	1	0
Western Hemlock	1	1.2	1	1
Pacific Silver Fir	0	0.0	0	1
Engelmann Spruce	0	0.0	0	1

[a] $N = 62$ paired sites.
[b] $N = 85$ total nest sites.

71 remaining nests were in trees <200 yr old; 50% of the nest trees were <130 yr old.

Eleven nest trees were residuals from previous stands largely destroyed by fire. The age of those 11 nest trees (mean = 314.7 yr, SD = 135.5, range = 155–550) was significantly greater than the age of the canopy dominant/codominant trees at each of these sites (mean = 135.6 yr, SD = 63.7, range = 77–228; $t = 4.87$, $P < 0.001$).

Nest trees were significantly larger (dbh) than random trees (Table 4, Fig. 2). In addition, nest trees on south-facing slopes were significantly larger (dbh mean = 76.4 cm, $N = 35$, SD = 30.5) than those on north slopes (mean = 58.2 cm, $N = 50$, SD = 18.8; Mann-Whitney test, $Z = 3.11$, $P = 0.002$). The 14 cavity/broken-top trees were significantly larger (mean = 94.7 cm, SD = 23.1) than the 71 others (mean = 59.4 cm, SD = 21.8; Mann-Whitney test, $Z = 5.39$, $P < 0.001$). Eight of nine cavity nest trees and two of five nest trees with broken-tops were on south slopes.

Table 2. Canopy position of Spotted Owl nest and random trees in the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison.

Canopy Position	Entire Sample	Paired Sample	
		Nest	Random
Dominant	24	15	13
Codominant	48	37	30
Intermediate	6	5	18
Suppressed	1	1	0
No crown	4	4	1

Table 3. Status of Spotted Owl nest and randomly selected trees in the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison.

		Paired Sample	
Status	Entire Sample	Nest	Random
Alive with intact top	59	43	53
Alive with intact, dead top	2	1	2
Alive with broken top	14	11	4
Dead with intact top	4	3	2
Dead with broken top	4	4	1

Nest tree height was not significantly different than the height of random trees (Table 4). Nest trees ranged from 7 (a broken snag) to 50 m tall. The height to the base of the canopy was significantly greater in nest trees than in random trees (Table 4). The mean height of nests was 16.9 m (SD = 6.9, range = 6.4–41.5). The position of nests in the canopy was variable, and appeared to be related to nest type (Table 5). Most nests (93%) occurred in the middle and lower canopy or the sub-canopy. Most nests (84.7%) were either on or immediately adjacent to the trunk. Eleven of 13

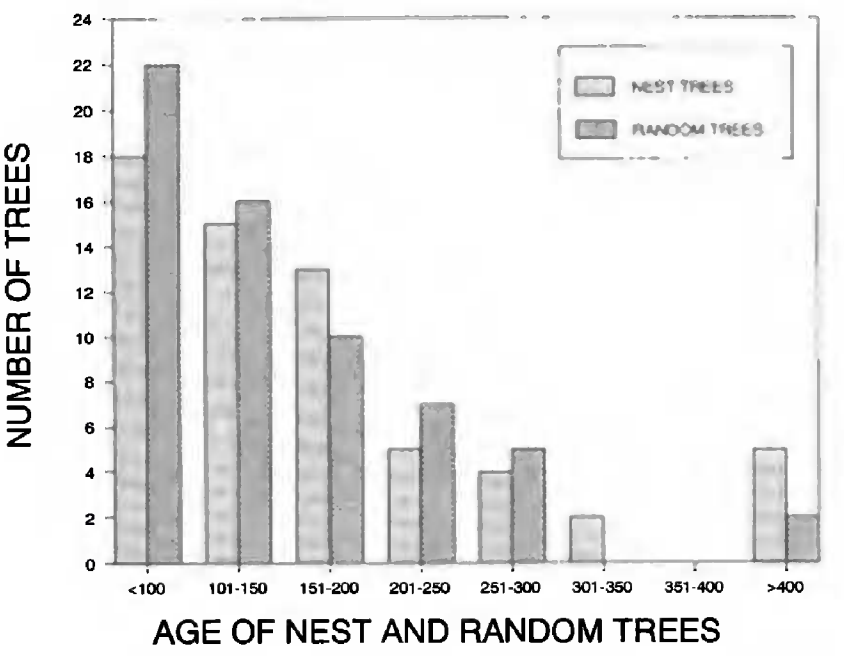

Figure 1. Frequency distributions of the age of Spotted Owl nest trees and randomly selected trees at 62 paired sites in the eastern Cascade Mountains, Washington.

Table 4. Comparison of Spotted Owl nest and random tree age, dbh (cm), and height (m) parameters from the eastern Cascade Mountains, Washington. Data for the entire sample are included for comparison. Standard deviations are in parentheses. *P* values based on paired analyses.

Parameter	Entire Sample	Paired Sample		
		Nest	Random	*P*
Tree age[a]	137.0	147.0	124.0	0.064
dbh	65.8	66.5	53.1	<0.001
	(25.7)	(25.9)	(20.6)	
Total height	31.0	30.4	28.6	0.190
	(8.0)	(8.2)	(7.3)	
Canopy height	15.5	15.7	13.0	0.005
	(5.2)	(5.6)	(5.6)	

[a] Values reported are medians. The median is a more appropriate descriptor because of the highly skewed distribution.

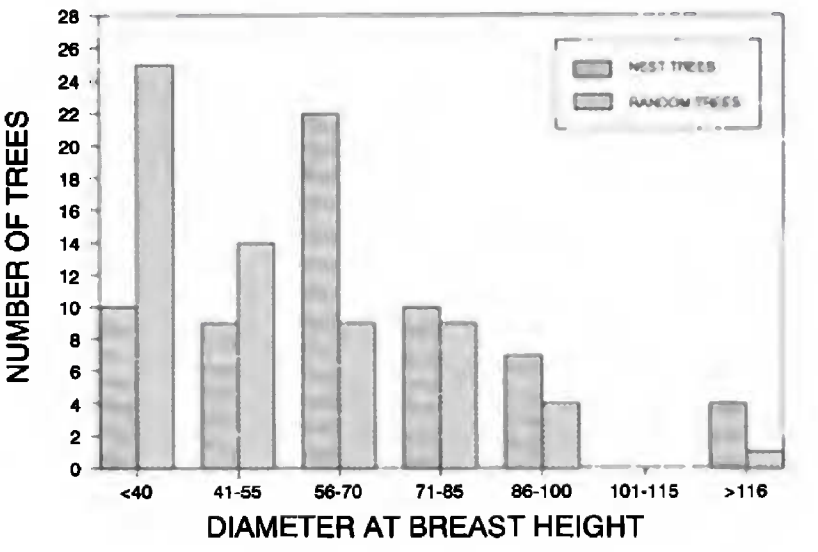

Figure 2. Frequency distributions of the diameter (cm) of Spotted Owl nest trees and randomly selected trees at 62 paired sites in the eastern Cascade Mountains, Washington.

other nests were <1 m from the trunk and the remaining 2 were <2 m from the trunk.

Although Spotted Owls used a variety of nest types, 2 types were more common than others: 47 (55%) were abandoned accipiter nests and 21 (25%) were within mistletoe brooms (not associated with an accipiter nest; see below). Most of the stick nests appeared to have been made by Northern Goshawks (*A. gentilis*). None of the randomly selected comparison trees contained nests. Because 35 (74%) of the abandoned accipiter nests were on mistletoe brooms, 56 (66%) Spotted Owl nests were either on or within mistletoe growth; this may be a slight underestimate because it was difficult to observe the upper surface of some mistletoe brooms. Other nests were in cavities (9), natural broken-top platforms (5), and on large branches adjacent to the trunk (3). The distribution of cavity and broken-top nests was significantly closer (mean = 19.0 km, SD = 12.7) to the Cascade Mountain crest than was that for hawk and mistletoe nests (mean = 30.9 km, SD = 13.7, $t = 2.9$, $P = 0.005$).

The mean angle of nest exposure relative to the trunk was southeast (mean angle = 131.9°, s [angular deviation] = 65.2°, r [a measure of concentration] = 0.35), and was significantly nonrandom ($Z = 10.3$, $P < 0.001$; Fig. 3). The mean angle for the sample of accipiter nests ($N = 47$) did not differ from this (mean angle = 128.1°, s = 68.5°, r = 0.29). The difference between slope aspect (20.1°; Buchanan 1991) and nest exposure was highly significant ($F = 28.5$, $P < 0.001$).

Discussion

Contrary to results from other regions in the Pacific Northwest, we found that Spotted Owls on the east slope of the Cascade Mountains in Washington nest in relatively smaller (e.g., 52% of nest trees were 53–76 cm dbh) and younger (median age = 137 yr) nest

Table 5. Position of Spotted Owl nests in canopy according to nest type (eastern Cascade Mountains, Washington).

Nest Type	Canopy Position					*N*
	Top ⅓	Mid ⅓	Low ⅓	Below	No Canopy	
Stick nest[a]	0	5	31	9	2	47
Mistletoe	1	4	14	2	0	21
Cavity	0	2	4	3	0	9
Broken-top	0	2	0	0	3	5
Branch	0	0	3	0	0	3
Total	1	13	52	14	5	85

[a] Includes 35 stick nests placed on top of small mistletoe clumps.

trees. This is consistent with Spotted Owl habitat use in this region, where relatively younger forests are available and used for nesting (Buchanan 1991). Consequently, comparisons of nest tree height and age between the WNF and study areas in Oregon (Forsman et al. 1984) and California (LaHaye 1988) reveal substantial differences that reflect differing regional patterns of disturbance, climate, and tree growth. Other nest tree characteristics appear similar to nest sites throughout the Pacific Northwest. In addition, there are a number of similarities to tree use by Northern Goshawks in the region; these are discussed below.

In our study, 92% of the nests were in Douglas-firs, and 88% of all trees were alive. Spotted Owls in Oregon and California nest almost exclusively in Douglas-firs (87% and 83%, respectively), most of which were alive (Forsman et al. 1984, LaHaye 1988). This is similar to findings for Northern Goshawks in this region (Reynolds et al. 1982, Moore and Henny 1983, Hayward and Escano 1989). This apparent preference for Douglas-fir can be explained partly by the observation that mistletoe infection is most prevalent in this tree species in the eastern Cascades (Knutson and Tinnin 1980). In addition, Douglas-fir may have branching characteristics that make them preferred sites for accipiter nest placement (but see Reynolds et al. 1982). Such selection for nest placement by accipiters may be influenced by the presence of mistletoe infections (Moore and Henny 1983).

The location within nest trees of cavity and broken-top nests in our study varied, but most mistletoe and stick nests were in the lower third of the canopy. We found only one nest in the upper third of the canopy. Forsman et al. (1984) noted that cavity nests occurred in the mid- to upper-third of the canopy and that platform nests were in the lower third. Use of stick nests located on lower portions of slopes (Buchanan 1991) represents typical nest placement by Northern Goshawks in the region (Hayward and Escano 1989).

Nest orientation relative to the tree trunk was southerly in our study (132°), as it is in California (201°; LaHaye 1988). This is similar to nest exposure data for Northern Goshawks in eastern Oregon (Reynolds et al. 1982, Moore and Henny 1983). Although 57% of the nests in our study were on north slopes, nest exposure at 63% of the sites was southerly. The primary reason for this was that most nests were on the uphill side of the tree. This upslope placement may be related to prey delivery behavior of Northern Goshawks. However, this does not fully explain the apparent preference for ESE and SE exposures. This

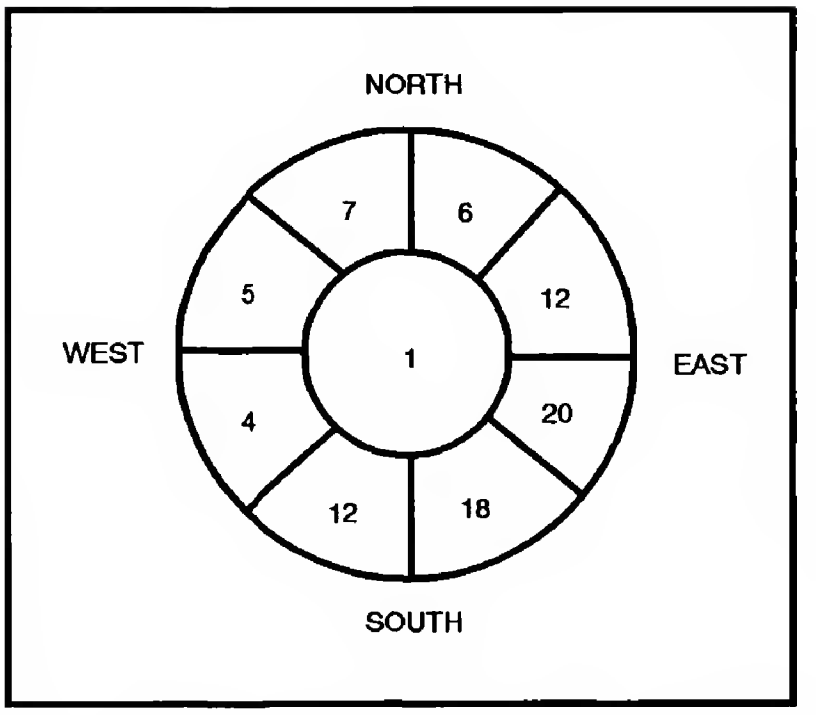

Figure 3. Frequency distribution of nest exposure at 85 Spotted Owl nest trees in the eastern Cascade Mountains, Washington.

apparent preference for nest exposure may reflect other important factors (e.g., protection from prevailing storm patterns, optimal thermoregulation).

In contrast to previous studies, we found that only 16% of the nests were in cavities or broken-topped trees and 80% were on mistletoe brooms or abandoned hawk nests. In western Oregon, most nests (81%) were in cavities and no nests were in mistletoe growth; 50% of the nests found in the Klamath Mountains of Oregon, an area of mixed coniferous forests, were on platforms (Forsman et al. 1984). In California, 80% of the nests were in cavities or broken-topped trees and 20% were on platforms of unknown origin (LaHaye 1988). In addition, we found that 89% of the mistletoe and hawk nests in the WNF were in trees <200 yr old. Of the 17 platform nests in the Klamath Mountains (Forsman et al. 1984), 9 were in old-growth trees, 7 were in trees 100–200 yr old, and 1 was in a tree 80 yr old. Because some of the nest sites in the WNF occur in younger stands that lack other nest structures (e.g., mistletoe), prior occupancy by goshawks appeared to be related to occupancy by Spotted Owls; this apparent relationship with Northern Goshawks has obvious management implications.

Use of open nest structures, such as abandoned hawk nests or tops of mistletoe clumps, appears to be more common in forests east of the Cascade crest than to the west (Forsman et al. 1984, this study). This regional difference may be related to constraints imposed by differing rainfall and moisture regimes in the two areas

(E. Forsman pers. comm.). In the WNF there is a gradient from moist fir/hemlock in the west to drier pine forests in the east (Franklin and Dyrness 1973). We found that cavity and broken-top nests were significantly closer to the Cascade crest than other nest types. The distribution of various nest types might therefore also be explained by differences in availability of nest types as a result of varying distributions of mistletoe and fire frequency.

The characteristics of Spotted Owl nest trees and nest sites in the WNF are a result of the fire and logging history of this region. We noted evidence of logging activity at 21% of the nest sites and 46% of the nest stands (Buchanan 1991). With two exceptions, these partial harvests occurred more than approximately 40 yr ago. These harvests removed healthy or larger trees and left any trees infected with mistletoe. This type of harvest simultaneously removed large trees that may have been suitable for nesting and also predisposed the young trees in the stand to mistletoe infestations (Buchanan 1991).

Prior to the onset of fire suppression in the WNF at the turn of the century, mixed coniferous forest communities were characterized by fire intervals of less than 50 yr (Cobb 1988). This frequent fire interval likely restricted the establishment of Grand Fir and resulted in landscapes dominated by fire resistant species such as Western Larch, Ponderosa Pine, and Douglas-fir (the latter species is fire resistant when mature). Research from other mixed coniferous forests indicates that Douglas-fir/Grand Fir forests have become more widely established in the current landscape only after relatively longer fire-free periods (e.g., Antos and Habeck 1981). Forests in some areas within the eastern Cascade Mountains province, because of their species composition, structural attributes, and fuel loads accumulated during the fire interval, are highly unstable and vulnerable to stand replacement fire (Kaufman 1990). Management plans must account for these forest landscape changes and the associated risk of catastrophic fire.

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